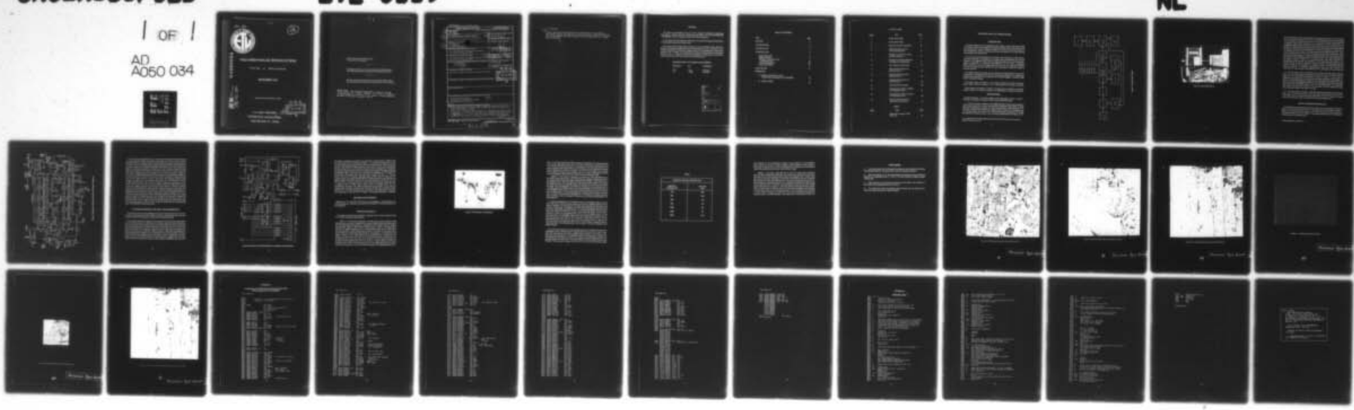
AD-A050 034 ARMY ENGINEER TOPOGRAPHIC LABS FORT BELVOIR VA F/G 9/3
HIGH SPEED PARALLEL SENSING SCHEME. (U)
DEC 77 P CHEN, W W SEEMULLER
UNCLASSIFIED ETL-0119 NL

1 OF 1
AD
A050 034



END
DATE
FILMED
3 — 78
DDC

ETL - 0119

12

AD A050034

HIGH SPEED PARALLEL SENSING SCHEME

Pi Fuay Chen and William W. Seemuller

DECEMBER 1977

Approved for public release; distribution unlimited

U.S. ARMY ENGINEER
TOPOGRAPHIC LABORATORIES
FORT BELVOIR, VA 22060

ERRATA SHEET: The original photographs of figures 8 through 11 and 14 are 8 by 8 inches. However, to be able to incorporate the photographs into the size of this report, a slight reduction was made to figures 8 through 11 and 14.

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
14 1. REPORT NUMBER ETL-Ø119	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
6 4. TITLE (and Subtitle) HIGH SPEED PARALLEL SENSING SCHEME.		9 5. TYPE OF REPORT & PERIOD COVERED Research Note
		6. PERFORMING ORG. REPORT NUMBER
10 7. AUTHOR(s) Pi-Fuay/Chen William W./Seemuller		8. CONTRACT OR GRANT NUMBER(s) 16
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer Topographic Laboratories Fort Belvoir, Virginia 22060		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 6.11.02.A, 4A161102B52C 02
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer Topographic Laboratories Fort Belvoir, Virginia 22060		11 12. REPORT DATE December 1977 17 92
		13. NUMBER OF PAGES 33
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) 12 39p.		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Solid State Sensor Arrays
Two-Dimensional Translational Stages
High Speed Parallel Scanning
Pixel
Imagery

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A high speed parallel scanning scheme is described that uses high density linear sensor arrays to convert optical images into electrical signals for computer processing or storage.
By using two 1,024-element linear arrays in a staggered line and x-y translational stages, a 9- by 9-inch transparency can be scanned and digitized into 8.5 [illegible] 10 pixels in 1 minute. Scan time can be reduced by increasing the slew rate of the stage or by increasing the scan line by using additional
continued

next page

DD FORM 1473, 1 JAN 73 — EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

time 10 to the 7th power

403 192

LB

20. continued

arrays. Since each array produces four simultaneous video signals, the system could be utilized as an input device for a parallel processor such as the STARAN. The video signals can be multiplexed onto a single line if desired.

PREFACE

This work was authorized by the U.S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia under DA Project-Task Area Work Unit No. 4A161102B 52C/ 1752CS20002, entitled "Application of Sensing Arrays to Mapping."

In this report, the final results are presented on the high speed parallel sensing scheme, which uses high density linear sensor arrays.

The authors extend thanks to Mr. R. Nelson for all the mechanical work involved in setting up the stage and modifying the heavy optical table, and to Mr. C. Johnson for constructing portions of the electronic hardware used for this experimentation. We are also grateful to Mr. R. Marth for reconstructing images from data tapes on the microdensitometer, to Mr. J.F. Merkel for reconstructing images from data tapes on the electron beam recorder, and to Mr. W. Daniels for the photographic work.

Conversion Factors: U.S. Customary Units to SI Metric

MULTIPLY	BY	TO OBTAIN
Inch	2.54	centimeter
mil	.0254	millimeter

TABLE OF CONTENTS

ILLUSTRATIONS

TABLE

HIGH SPEED PARALLEL SENSING SCHEME

INTRODUCTION

The major objective of this investigation was to devise a system that could increase the digitizing speed of photographs for mapping applications. Solid state sensor arrays were chosen as the system transducer because of the fixed and accurate position of the photosensitive elements comprising an array and because of the rapid scanning speed possible with these devices.

For our study and experimentation, two linear arrays consisting of 1,024 elements each were positioned in a staggered line to achieve even pixel separation in the x-scan direction. Nine staggered arrays would be needed for scanning a 9- by 9-inch photographic transparency. An Aerotech two-dimensional, 10- by 10-inch, translational stage* was used to scan the transparencies over the arrays. The stage was controlled by both the special purpose hardware and the minicomputer to give three modes of scanning operation.

The digital hardware controller and the electronic interface between the array and minicomputer were designed and built with commercially available TTL components. Software was developed in both assembly and Fortran languages to implement stage control and signal processing.

The overall system was tested in three modes of operation using the in-house designed digital electronic hardware or the minicomputer as the system controller.

Good results were obtained in relation to the scan time and quality of the reconstructed imagery. The scheme proved to be encouraging for mapping applications.

INVESTIGATION

System Description. The block diagram of the total system is shown in figure 1. The system was designed to operate in three modes as described below.

1. In the first mode of operation, two staggered Reticon linear arrays consisting of 1,024 elements each were used to produce eight simultaneous video signals. A white light source powered by a variable d.c. supply was positioned under the center of an Aerotech two-dimensional translational stage as shown in figure 2. The stage was used to hold the imagery, which was a 9- by 9-inch photographic transparency. The stage was capable of moving in both x and y directions approximately 10 inches. A mir-

*For an explanation of the translational stage, see the *Aerotech Unidex D C Position Servo Instruction Manual*, Aerotech Inc., Allison Park, Pa., nd.

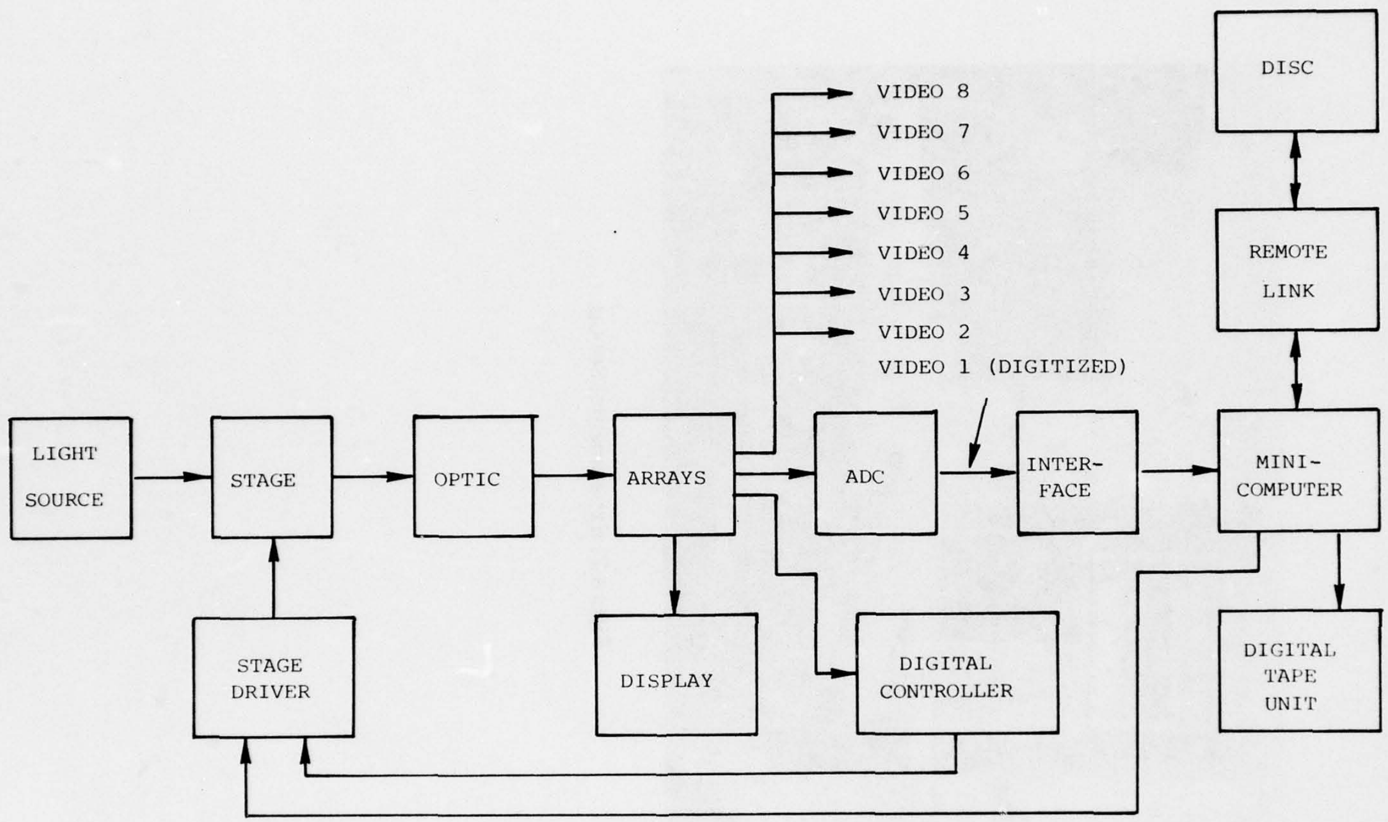


Figure 1. System Block Design

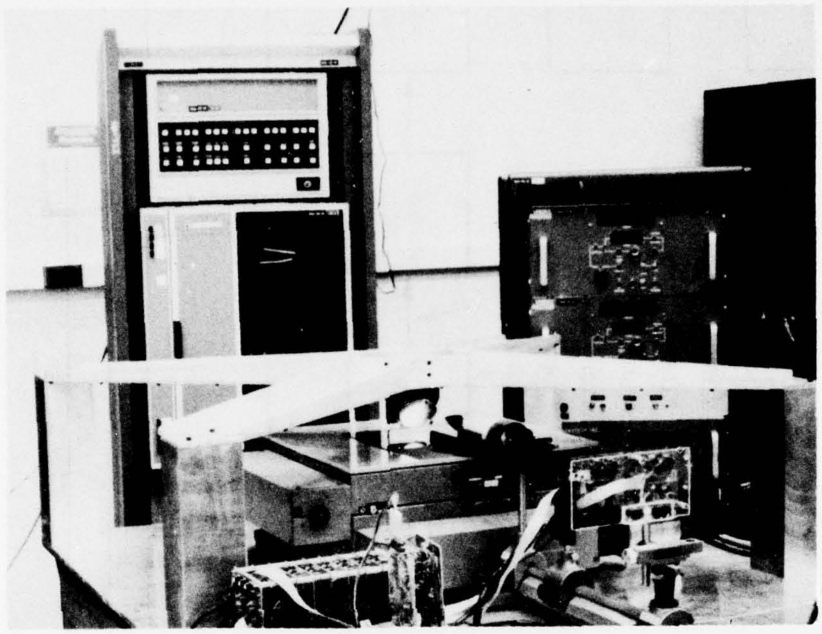


Figure 2. Experimental Set-up.

ror was mounted at a 45 angle just above the transparency (see figure 2). The portion of the imagery illuminated by the light source was reflected by this mirror and imaged onto the surface of the arrays with a lens. The lens and the arrays were mounted on a triangular optical bench, which was in turn mounted on a heavy optical table. The translational stage was also mounted on this optical table to minimize relative motion between the imagery and the arrays during scanning. The position of the lens between the imagery and the arrays was adjusted by a micrometer attached to the lens mount to produce one-to-one imaging. The stage was driven by digital electronics to scan a 2-inch, vertical strip across the arrays. This digital controller will be described in detail later. After scanning one strip, the stage changed direction and the next adjacent strip was scanned in the opposite direction. The scanning path of the stage with respect to the arrays is shown in figure 3. As mentioned earlier, each array produced four simultaneous video channels. The sequence of the video signals with respect to the physical position of the array elements is shown in figure 4. The eight video channels from two arrays can be interfaced to a parallel computer through ADCS (analog to digital converters). To facilitate experimentation, only one video channel was interfaced. All video channels were displayed on an oscilloscope for visual inspection.

2. For the second mode of operation, only one linear array was used for sensing. One of the four video channels was digitized by a DATEL, Model HV-100 ADC before being sent to the HP-2100 minicomputer as shown in figure 1. In this mode of operation, the minicomputer was used as both the signal processor and the stage controller. The digitized data were processed by the minicomputer and stored onto magnetic tape using a HP-7970B digital tape unit. The stored data were then reconstructed offline using the DICOMED system* and the microdensitometer. The undesirable dark noise of the array was removed in the computer. The same light source, stage, and optics used in Mode 1 were used in this case.

3. In the last mode of operation, a remotely located disc was used to store the digitized data. This was done so that a final data tape could be written in a true 9- by 9-inch raster scan from the data stored in strip fashion on the disc. However, the serial link to the remote disc greatly increased the total data acquisition time.

DIGITAL HARDWARE CONTROLLER

The digital hardware was designed and built to move the two-dimensional translation stage in the scan path shown in figure 3. The schematic of this controller is shown in figure 5. The controller consists mainly of two sets of counters for motor step count indexing and other circuits for direction drive, pulse gating, and timing. The operation of this controller is described below.

*Registered trademark for DICOMED, Inc.

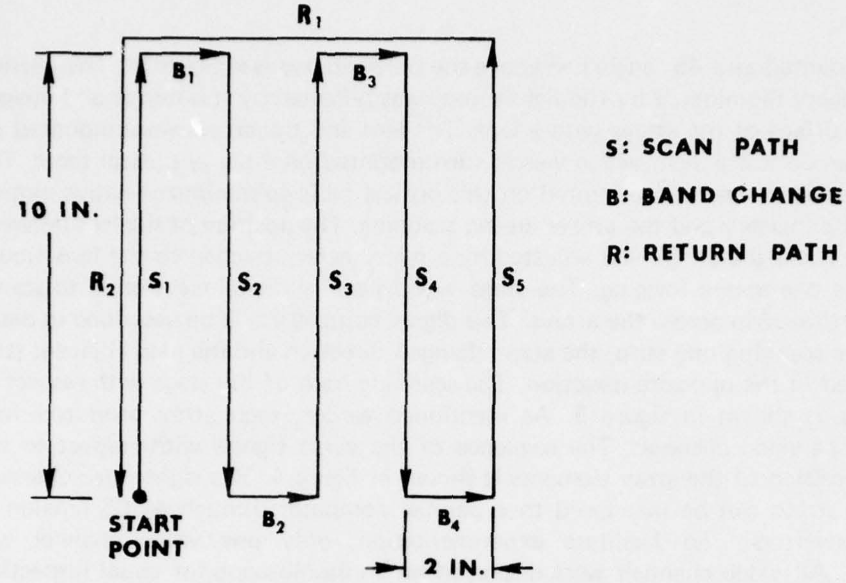


Figure 3. Scan Path for Mode 1 Operation.

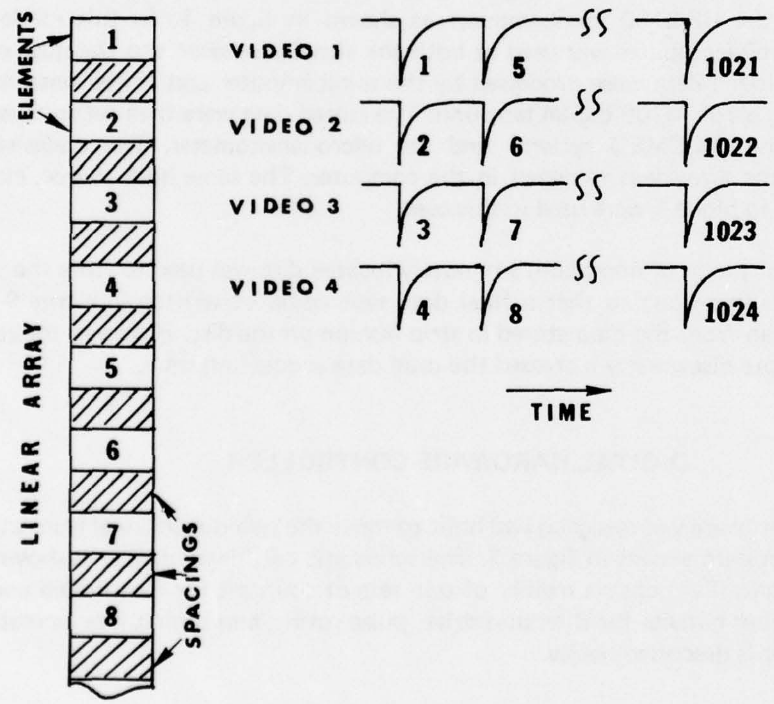


Figure 4. Video Sequence and Array Element Configuration.

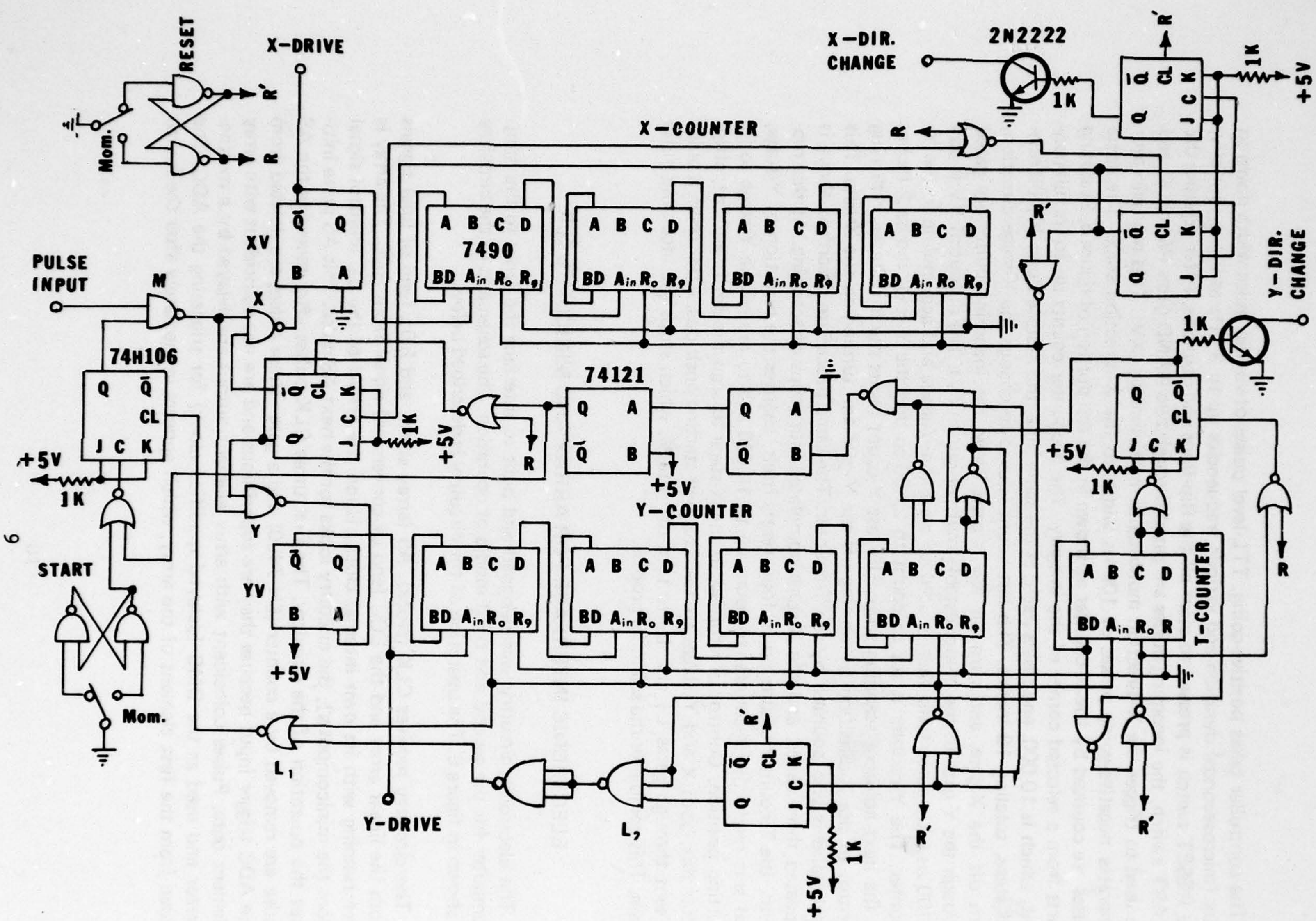


Figure 5. Schematic of System Controller for Mode 1 Operation

The controller takes positive-going, TTL-level pulses of various pulse width down to 1 μs (microseconds) duration and various frequencies up to 3 kHz as input. Initially, the RESET switch is pressed to clear all the flip-flops and counters. After pressing the START switch, the incoming pulses are gated through two NAND gates (M and X) and are used to trigger the X-direction monostable multivibrator (XV). This multivibrator generates negative-going pulses of 100 μs width to the X-direction stage. The same pulses are counted by the X-counter as shown in the top portion of figure 5. Scanning starts from a selected corner of the imagery. The X-counter counts up to its full content, which is 10,000, and resets itself; at the same time, the X-stage slews 10,000 one-mil steps, totaling 10 inches. The last count is used to change the X-stage direction, turn off the X-gate, and turn on the Y-gate. Now, the incoming pulses are gated through the Y-gate to the Y-monostable multivibrator (YV). The output of YV is also a 100 μs-wide-pulse train that is used to slew the Y-stage and accumulate in the Y-counter. The Y-counter is set to count to 2,000 so that the Y-stage moves 2 inches to the next adjacent scanning strip. The last Y-count resets the Y-counter, returning control to the X-direction by turning off the Y-gate and turning on the X-gate. This reset pulse is also counted by the T-counter. The same procedure described above is repeated three times, and the X-stage completes four strips of scanning. At this moment, the T-counter counts up to four, resets itself, changes the direction of Y-stage, and sets ready the Y-counter to count up to 10,000 and to return the Y-stage to its starting position. Control is returned to the X-stage to scan the fifth, and last, strip. After this, both X and Y stages are reset to their starting positions. After reset, a pulse is sent through gates L_1 and L_2 to turn off gate M, which stops the incoming pulse train. This completes the scanning process.

ELECTRONIC INTERFACE FOR ARRAY AND MINICOMPUTER

The electronic circuitry was designed and built to interface the array to the minicomputer for the second and third modes of operation. The schematic of the circuitry is shown in figure 6. The operation of the circuitry is described below.

The circuitry receives CLK (clock), AS (array start), and EOL (end of line) signals from the linear array and the EOC (end of conversion) signal from ADC. The array is free running with its own internal clock. Upon the arrival of the CC (control signal from the minicomputer), the circuitry looks for the next AS pulse. This AS pulse initiates the operation of the circuitry. The first three CLK pulses after receiving the AS pulse are removed by a counter (SN 7490) and a gate. These pulses are deleted from the ADC trigger input because they are superfluous and are not coincident with array element data. Pulses coincident with array element output are delayed by a multivibrator and used as the DMC (delayed modified clock) for triggering the ADC. The video from the first element of the array, which appears immediately after the fourth

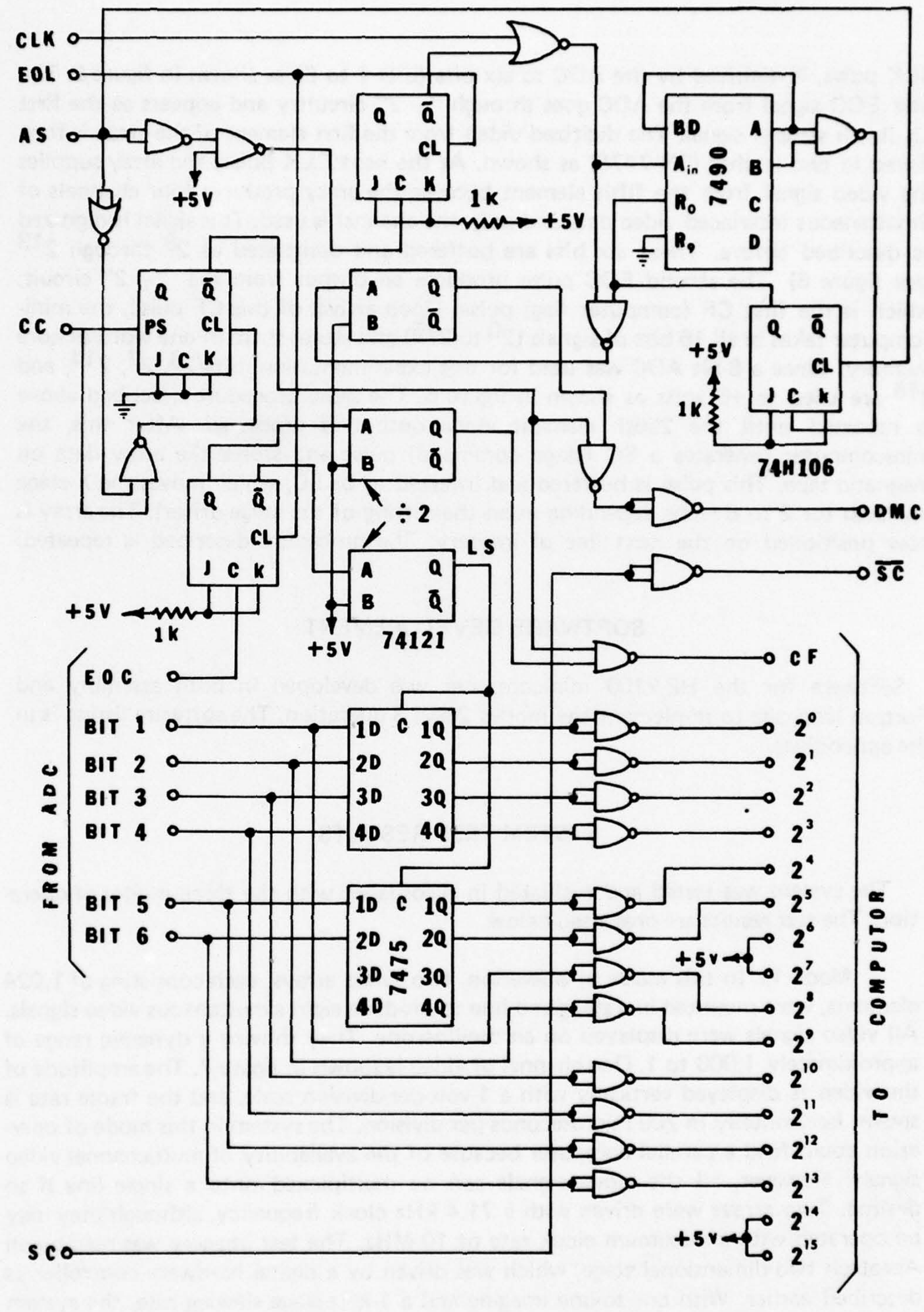


Figure 6. Schematic of Interface Electronic for Modes 2 and 3 Operations

CLK pulse, is digitized by the ADC to six bits (bits 1 to 6) as shown in figure 6. The first EOC signal from the ADC goes through "÷ 2" circuitry and appears as the first LS (latch strobe) signal. The digitized video from the first element of the array is then stored in two latches (SN 7475) as shown. At the next CLK pulse, the array supplies the video signal from the fifth element because the array produces four channels of simultaneous interlaced video data and only one channel is used. This signal is digitized as described before. These six bits are buffered and designated as 2^8 through 2^{13} (see figure 6). The second EOC pulse produces an output from the "÷ 2" circuit, which is the first CF (computer flag) pulse. Upon arrival of this CF pulse, the minicomputer takes in all 16 bits of signals (2^0 to 2^{15}) and stores them in one word of core memory. Since a 6-bit ADC was used for this experimentation, bits 2^6, 2^7, 2^{14}, and 2^{15} are tried to +5 volts as shown in figure 6. The same procedure described above is repeated until the 256th element video output is processed. After this, the minicomputer generates a SC (stage command) pulse and stores the array data on magnetic tape. This pulse is buffered and inverted to be $\overline{SC}$, which moves the X-stage one step (or 2 to 8 steps depending upon the setting of the stage driver). The array is now positioned on the next line of imagery. The procedure described is repeated.

SOFTWARE DEVELOPEMENT

Software for the HP-2100 minicomputer was developed in both assembly and Fortran language to implement the modes 2 and 3 operation. The software listing is in the appendixes.

SYSTEM TEST RESULTS

The system was tested and evaluated in accordance with the three modes of operation. The test results are presented below.

Mode 1. In this mode of operation, two linear arrays, each consisting of 1,024 elements, were mounted in a staggered line to produce eight simultaneous video signals. All video signals were displayed on an oscilloscope. They showed a dynamic range of approximately 1,000 to 1. One channel of video is shown in figure 7. The amplitude of the video is displayed vertically with a 1-volt-per-division scale, and the frame rate is shown horizontally in 200 microseconds per division. The system in this mode of operation could feed a parallel computer because of the availability of multichannel video signals. However, all the video signals can be multiplexed onto a single line if so desired. Two arrays were driven with a 71.4 kHz clock frequency, although they may be operated with a maximum clock rate of 10 MHz. The test imagery was held by an Aerotech two-dimensional stage, which was driven by a digital hardware controller as described earlier. With one-to-one imaging and a 1-kHz-stage slewing rate, the system scanned and digitized a 9- by 9-inch photo-transparency into 84,934,656 pixels of 1

Figure 7. CRT Display of Video Signal.

mil by 1 mil, each consisting of 256 gray shades, in 58 seconds. The system was tested with various stage slewing rates, and a very linear relationship was obtained, up to 3 kHz driving frequency (see table 1). Overslewing of the stage occurred when the driving frequency was raised beyond 3.5 kHz. Smaller pixel size is possible with greater image magnification and with an increase in scan time. The converse is true if a larger pixel is desired. The best scanning scheme for 9- by 9-inch transparencies would be to use nine staggered linear arrays and a single direction translational stage.

Mode-2. In this mode of operation, one channel of video was digitized by a 6-bit ADC, before being sent to the minicomputer for storage on magnetic tape. Since the dynamic range of the video signal is approximately 1,000 to 1, the video data may be digitized to 8 or 10 bits for applications requiring more gray shades. In our system, the digital data from two adjacent pixels were packed into one 16-bit word before being sent to the minicomputer. The images on the tapes were then reconstructed by a remotely located DICOMED system or a microdensitometer. To match the format of the DICOMED device, only an 8- by 8-inch area was scanned from the 9- by 9-inch photo transparencies. It took approximately 16 minutes to scan and store the digital data for the 8- by 8-inch area of transparency. The increase in the system operation time compared to that of the Mode-1 is mainly due to the slow writing speed of the digital tape unit.

Two aerial photographs from the Baltimore area, a photographic plate of an Oklahoma scene, and a grid plate were scanned and stored on magnetic tapes using this mode of operation. The contents of the tapes were reconstructed into hard copies 3 5/8 by 3 5/8 inches. The original 8- by 8-inch photographs were developed from these hard copies (See figures 8 through 11). The aerial photographs from the Baltimore area (figures 8 and 9) and the scene from Oklahoma (figure 10) were reconstructed by using the mocrodensitometer, and the grid photograph (figure 11) was reconstructed by the DICOMED system. Each figure shows good resolution and contrast, and accurate pixel position. The pixel size for these figures is 4 by 4 mil. The lines between each scan strip are due to uneven illumination from the light source. This also caused the sudden gray shade change of some patterns overlapping two adjacent scan strips. The undesirable black lines in figure 11 are due to scratches on the original imagery.

A 2- by 2-inch section from the first aerial photograph of the Baltimore area and the photographic plate of Oklahoma were magnified four times in both the X and Y directions and were scanned and stored on magnetic tapes as before. The contents of the tapes were reconstructed by the DICOMED system, and phtotgraphs of original size were developed (See figures 12 and 13). Comparison of these photographs with corresponding sections in figures 8 and 10 clearly indicates that much higher resolution was obtained. The pixel size for figures 12 and 13 is 1 by 1 mil. Only 2-inch-square images

Table 1

Stage Drive Frequency versus Scan Time

Stage Drive Frequency (Hz)	Scan Time (Sec)
100	580
200	290
300	193
500	116
1000	58
2000	29
3000	19.3

were selected for this demonstration because of the limitation of the DICOMED system (maximum number of pixels is 2,048 by 2,048). Resolution exactly equal to that shown in figures 12 and 13 can be obtained by multiplexing four simultaneous video channels electronically without magnifying the images.

Mode-3. To produce a data tape with a true 9- by 9-inch raster compatible with the EBR (Electron Beam Recorder), the software was modified to store the digitized data onto a remotely located disc through a communication link. The data on the disc in strip mode were rearranged in the format of the EBR and stored on magnetic tape through the same communication link. The system's operation time was not reduced because the digitized data had to be converted to a serial string to pass through the communication link. This effort was unsuccessful from the point of view of saving system operation time. However, if a disc were located online with the array scanner and the minicomputer, a reduction factor of 16.6 in system operation time is possible. This will again reduce the 16 minutes operation time of the Mode 2 into less than 1 minute. Figure 14 shows the preliminary result of the reconstructed image of the Oklahoma area by the EBR operated in the analog mode. The pixel size is 4 by 4 mil.

CONCLUSIONS

1. High speed scanning of photographic transparencies was successfully demonstrated using high resolution, solid state, linear arrays as the optical transducer.

2. With this method, a 9- by 9-inch photographic transparency can be scanned and digitized into 84,934,656 pixels of 1 mil by 1 mil each consisting of 256 gray shades, in 58 seconds.

3. High resolution, good contrast, and accurate pixel position were obtained in the reconstructed images scanned by this method.

4. The scheme also offers simultaneous parallel outputs that can readily be connected to a parallel processor for rapid processing.

Figure 8. Reconstructed Image of the Baltimore Area 1.

Preceding Page Blank

Figure 9. Reconstructed Image of the Baltimore Area 2.

Preceding Page Blank

Figure 10. Reconstructed Image of the Oklahoma Area.

Preceding Page Blank - F

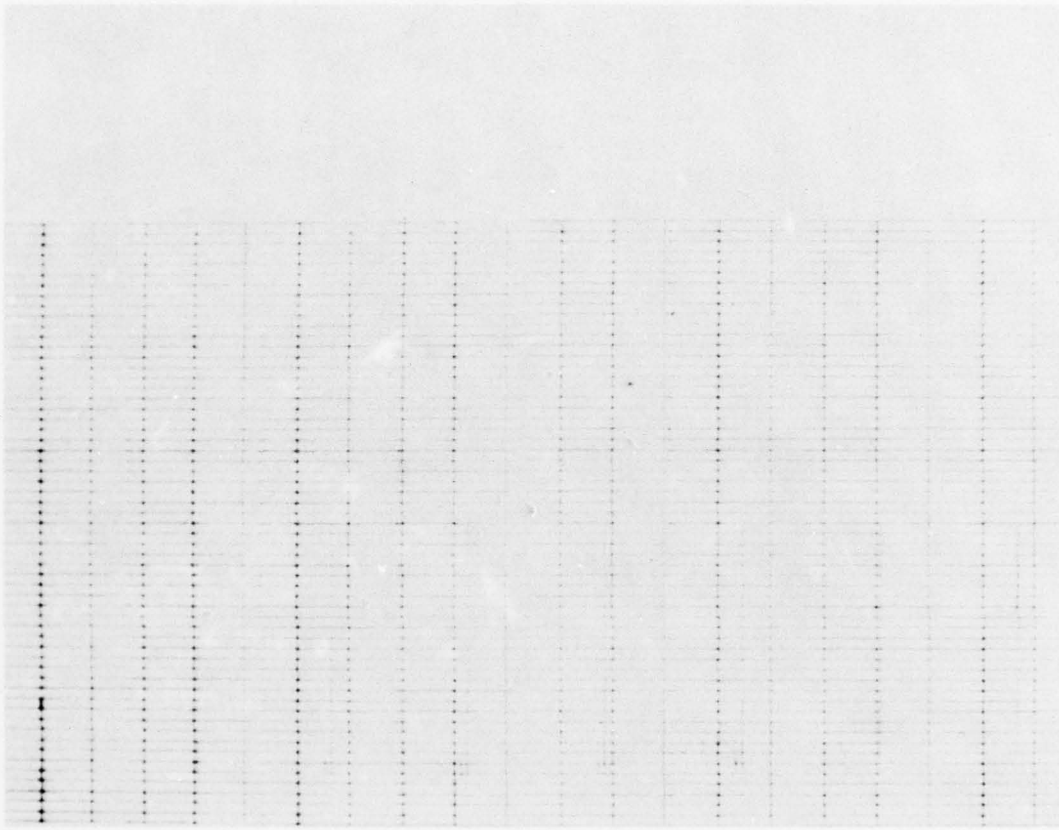


Figure 11. Reconstructed Grid Image.

Preceding Page Blank

Figure 12. Reconstructed Image for a Section of the Baltimore Area 1.

Preceding Page Blank

Figure 13. Reconstructed Image for a Section of the Oklahoma Area.

Preceding Page Blank

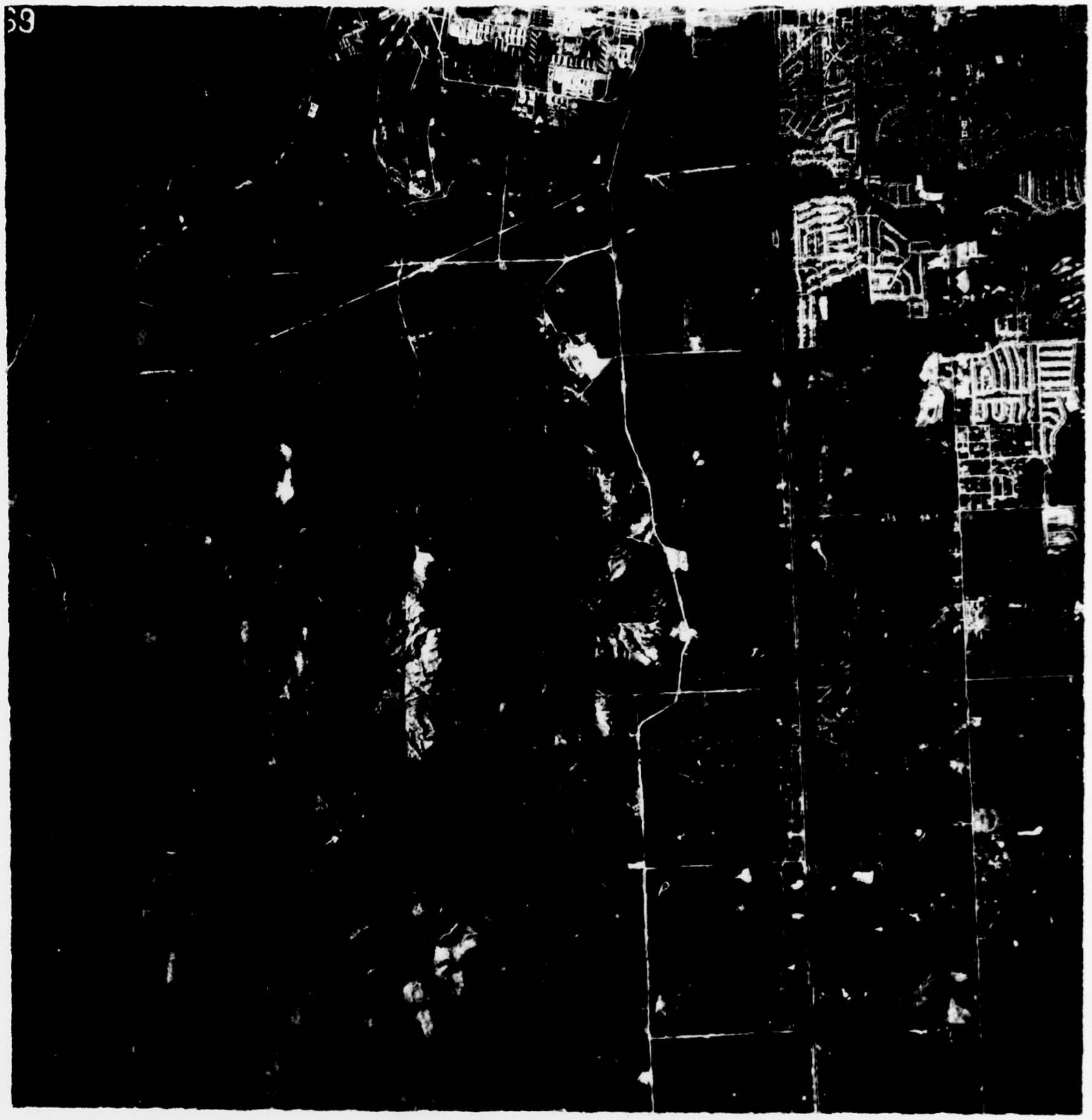


Figure 14. Reconstructed Image of the Oklahoma Area with EBR.

Preceding Page Blank

APPENDIX A

A PROGRAM TO STORE BINARY IMAGE ON MAG TAPE FOR PLAYBACK ON THE DICOMED

```
PAGE 0002 #01

*
*         PROGRAM TO STORE BINARY IMAGE ON MAG TAPE FOR
*         PLAYBACK ON THE DICOMED.
*
*
00000                      NAM ISCAN
                           ENT ISCAN
                           EXT .IOC.,ASOUT,NUMIN,FINPT
                           EXT UNPAC,MMOVE
                           EXT DELAY
00000 000000  ISCAN        NOP
00001 063206R              LDA =B10
00002 007400               CCB
00003 016004X              JSB FINPT        INPUT DARK LEVELS
00004 000406R              DEF BUFER
00005 000326R              DEF N
*
00006 062326R              LDA N
00007 001200               RAL
00010 066161R              LDB BUFAD
00011 016005X              JSB UNPAC        UNPACK INTO DARK BUFFER
00012 000606R DKADR        DEF DARK
*
00013 062326R              LDA N
00014 001200               RAL
00015 003004               CMA,INA
00016 072364R              STA CNT1
00017 066012R              LDB DKADR
00020 160001               LDA 1,I          MAKE DARK
00021 003004               CMA,INA           LEVELS
00022 170001               STA 1,I            NEGATIVE
00023 006004               INB
00024 036364R              ISZ CNT1
00025 026020R              JMP *-5
*
00026 002400  L0           CLA
00027 102601               OTA 1
*
00030 063207R LL1          LDA =B2000
00031 043210R              ADA =D14
00032 066337R              LDB MAD1
00033 016002X              JSB ASOUT        ASK FOR NO. OF STRIPS
00034 000151R              DEF RETRN
00035 026147R              JMP END
00036 016003X              JSB NUMIN        INPUT NO. OF BLOCKS
00037 000151R              DEF RETRN
00040 026147R              JMP END
00041 026030R              JMP LL1
00042 067211R              LDB =D2048
00043 002020               SSA            NEG. X MOTION?
00044 007004               CMB,INB        YES, STORE
00045 076370R              STB BSTEP      NEG. BLOCK STEPS
00046 002021               SSA,RSS
00047 003004               CMA,INA
00050 072372R              STA NBLKS
00051 043206R              ADA =D8
00052 002020               SSA              MORE THAN 8?
```

```
PAGE 0003 #01

00053 026030R        JMP LL1
*
00054 063207R L1     LDA =B2000
00055 043212R        ADA =D18
00056 066347R        LDB MAD2
00057 016002X        JSB ASOUT      ASK FOR NO. OF LINES
00060 000151R        DEF RETRN
00061 026147R        JMP END
00062 016003X        JSB NUMIN
00063 000151R        DEF RETRN
00064 026147R        JMP END
00065 026054R        JMP L1
00066 067206R        LDB =D8
00067 002020         SSA          NEG. Y MOTION?
00070 007004         CMB,INB       YES, MAKE -1
00071 076367R        STB LSTEP
00072 002021         SSA,RSS
00073 003004         CMA,INA
00074 072371R        STA NLINS
00075 002400         CLA
00076 072373R        STA XSET       SET STAGE POSITIONS
00077 072374R        STA YSET        TO ZERO
00100 003000         CMA
00101 072402R        STA LASTX
*
00102 002400  L2     CLA          SET X
00103 072375R        STA XSTEP    STEPS = 0
00104 062367R        LDA LSTEP     SET Y STEP
00105 072376R        STA YSTEP     =+-1
00106 062371R        LDA NLINS
00107 072365R        STA CNT2       LINE COUNTER
00110 102501  L3     LIA 1
00111 002020         SSA           ABORT?
00112 026137R        JMP START
00113 016155R        JSB READ       INPUT AND ROTATE
00114 016316R        JSB WRITE      WRITE ON MAG TAPE
00115 036365R        ISZ CNT2       ALL LINES DONE?
00116 002001         RSS
00117 026122R        JMP *+3
00120 016246R        JSB SLEW       MOVE TO NEXT LINE
00121 026110R        JMP L3
00122 036372R        ISZ NBLKS      ALL STRIPS DONE?
00123 002001         RSS
00124 026133R        JMP EOF        YES, WRITE EOF, REWINDE
00125 062374R        LDA YSET       RESET TO
00126 072376R        STA YSTEP       TO TOP LINE
00127 062370R        LDA BSTEP     MOVE TO
00130 072375R        STA XSTEP     NEXT STRIP
00131 016246R        JSB SLEW
00132 026102R        JMP L2
*
00133 016001X EOF    JSB .IOC.
00134 030103         OCT 30103
00135 000000         NOP
00136 016331R        JSB WAIT
00137 016001X START  JSB .IOC.
00140 030403         OCT 30403
```

```
00141 000000         NOP
00142 062373R        LDA XSET
00143 072375R        STA XSTEP
00144 062374R        LDA YSET
00145 072376R        STA YSTEP
00146 016246R        JSB SLEW         SLEW BACK TO START
00147 102077  END    HLT 77B
00150 026026R        JMP L0
*
*
00151 000000  RETRN  NOP
00152 102501         LIA 1
00153 013213R        AND =B100000
00154 126151R        JMP RETRN,I
*
00155 000000  READ   NOP
00156 063206R        LDA =B10
00157 007400         CCB
00160 016004X        JSB FINPT
00161 000406R BUFAD  DEF BUFER
00162 000326R        DEF N
00163 062326R        LDA N
00164 003004         CMA,INA
00165 072364R        STA CNT1
00166 062012R        LDA DKADR
00167 072366R        STA CNT3
00170 066161R        LDB BUFAD
00171 160001  L4     LDA 1,I
00172 001727         ALF,ALF
00173 013214R        AND =B377
00174 142366R        ADA CNT3,I       SUB. DARK LEVEL
00175 002020         SSA             MAKE 0
00176 002400         CLA              IF NEG.
00177 072405R        STA TEMP
00200 102501         LIA 1        IF BIT 0=1
00201 002011         SLA,RSS        CLIP VIDEO DATA
00202 026214R        JMP L5
00203 062405R        LDA TEMP
00204 003004         CMA,INA
00205 042362R        ADA CLIP
00206 002020         SSA
00207 026212R        JMP *+3
00210 002400         CLA
00211 026213R        JMP *+2
00212 062363R        LDA MAX
00213 072405R        STA TEMP
00214 036366R L5     ISZ CNT3
00215 160001         LDA 1,I
00216 013214R        AND =B377
00217 142366R        ADA CNT3,I
00220 072361R        STA TMP
00221 102501         LIA 1
00222 002011         SLA,RSS
00223 026233R        JMP L6
00224 062361R        LDA TMP
00225 003004         CMA,INA
00226 042362R        ADA CLIP
```

```
00227 002021              SSA,RSS
00230 026235R             JMP *+5
00231 062363R             LDA MAX
00232 026236R             JMP *+4
00233 062361R L6          LDA TMP
00234 002020              SSA
00235 002400              CLA
00236 001727              ALF,ALF
00237 032405R             IOR TEMP
00240 170001              STA 1,I
00241 006004              INB
00242 036366R             ISZ CNT3
00243 036364R             ISZ CNT1
00244 026171R             JMP L4
00245 126155R             JMP READ,I
*
*
00246 000000  SLEW        NOP
00247 062402R             LDA LASTX
00250 022375R             XOR XSTEP
00251 002020              SSA
00252 026257R             JMP DIROT
00253 062403R             LDA LASTY
00254 022376R             XOR YSTEP
00255 002021              SSA,RSS
00256 026272R             JMP MOVE
00257 063215R DIROT       LDA =B77774
00260 066375R             LDB XSTEP
00261 006020              SSB
00262 002004              INA
00263 066376R             LDB YSTEP
00264 006020              SSB
00265 033216R             IOR =B2
00266 102621              OTA 21B
00267 016007X             JSB DELAY
00270 000272R             DEF *+2
00271 000401R             DEF MASK
00272 016006X MOVE        JSB MMOVE
00273 000303R             DEF RTN
00274 000375R             DEF XSTEP
00275 000376R             DEF YSTEP
00276 000377R             DEF RATE
00277 000400R             DEF PAUSE
00300 000401R             DEF MASK
00301 000401R             DEF MASK
00302 000404R             DEF CHAN
00303 062375R RTN         LDA XSTEP
00304 072402R             STA LASTX
00305 003004              CMA,INA
00306 042373R             ADA XSET
00307 072373R             STA XSET
00310 062376R             LDA YSTEP
00311 072403R             STA LASTY
00312 003004              CMA,INA
00313 042374R             ADA YSET
00314 072374R             STA YSET
00315 126246R             JMP SLEW,I
```

```
*
*
00316 000000  WRITE NOP
00317 026322R       JMP *+3
00320 016001X       JSB .IOC.
00321 000007        OCT 7
00322 016001X       JSB .IOC.
00323 020103        OCT 20103
00324 026320R       JMP *-4
00325 000406R       DEF BUFER
00326 000200  N     DEC 128
00327 016331R       JSB WAIT
00330 126316R       JMP WRITE,I
*
*
00331 000000  WAIT  NOP
00332 016001X       JSB .IOC.
00333 040003        OCT 40003
00334 002020        SSA
00335 026332R       JMP *-3
00336 126331R       JMP WAIT,I
*
00337 000340R MAD1  DEF *+1
00340 047117        ASC 7,NO. OF STRIPS?
00341 027040
00342 047506
00343 020123
00344 052122
00345 044520
00346 051477
00347 000350R MAD2  DEF *+1
00350 047117        ASC 9,NO. OF SCAN LINES?
00351 027040
00352 047506
00353 020123
00354 041501
00355 047040
00356 046111
00357 047105
00360 051477
00361 000000  TMP   NOP
00362 000040  CLIP  DEC 32
00363 000077  MAX   DEC 63
00364 000000  CNT1  NOP
00365 000000  CNT2  NOP
00366 000000  CNT3  NOP
00367 000000  LSTEP NOP
00370 000000  BSTEP NOP
00371 000000  NLINS NOP
00372 000000  NBLKS NOP
00373 000000  XSET  NOP
00374 000000  YSET  NOP
00375 000000  XSTEP NOP
00376 000000  YSTEP NOP
00377 000144  RATE  DEC 100
00400 000000  PAUSE NOP
00401 000017  MASK  OCT 17
```

```
0272  00402 000000  LASTX NOP
0273  00403 000000  LASTY NOP
0274  00404 000021  CHAN  OCT 21
0275  00405 000000  TEMP  NOP
0276  00406 000000  BUFER BSS 128
0277  00606 000000  DARK  BSS 256
      01206 000010
      01207 002000
      01210 000016
      01211 004000
      01212 000022
      01213 100000
      01214 000377
      01215 077774
      01216 000002
0278                      END ISCAN
**  NO ERRORS*
```

APPENDIX B

PROGRAM ARSCN

```
FTN,B
          PROGRAM ARSCN
          DIMENSION IBUF(1025),NAME(3)
          DIMENSION IDARK(256)
          DIMENSION LU(2),IO(2),IPIXL(2)
C
C         GET LU AND CHANNEL OF THE MCI CARDS.  THE
C         FIRST CARD IS USED FOR DATA INPUT AND
C         THE SECOND CARD IS USED TO SLEW THE STAGES.
C
          CALL LUNIT(14B,LU,IO)
          IF (LU.NE.0)GO TO 6
          WRITE(2,5)
5         FORMAT("D.14 NOT PRESENT")
          CALL IDLE
C
C         INPUT THE NUMBER OF BITS IN THE DATA.  THE HARDWARE
C         REVERSES THE THE ORDER OF THE TWO 8 BIT PIXELS IN
C         THE 16 BIT INPUT WORD.  ACCORDING TO THE HIGHEST
C         SIGNIFICANT BIT DESIRED IN THE DATA, THE SIX BIT
C         PIXEL FROM THE A/D CONVERTER(RIGHT JUSTIFIED IN
C         8 BITS), IS ROTATED TO THE LEFT BY
C         NBITS. (NBITS=-6 FOR AN 8 BIT RANGE).
C
6         WRITE(2,7)
7         FORMAT("NO. OF BITS?")
          READ(1,*)I
          IF (IRANG(6,8,I))6,8
8         NBITS=I-14
C
C         SET THE DARK LEVLES TO 0
C
          DO 9 I=1,256
9         IDARK(I)=0
C
C         INPUT THE ARRAY DARK LEVELS IF TTY RESPONSE > 0.
C
10        CALL IOUT(0,1)
          WRITE(2,11)
11        FORMAT("INPUT DARK LEVELS? (INPUT>0)")
          READ(1,*)I
          IBUF=0
          IF (I.LT.1)GO TO 12
          CALL DMAIN(IBUF(2),128,LU)
          CALL ROTAT(IBUF(2),IBUF(2),128,NBITS)
          CALL UNPAK(IBUF(2),IDARK,256)
C
C         CREATE DATA FILE OR OPEN EXISTING FILE
C
12        WRITE(2,20)
20        FORMAT("CREATE FILE? (INPUT>0)")
          READ(1,*)I
          WRITE(2,30)
30        FORMAT("FILE NAME?")
          READ(1,40)NAME
40        FORMAT(3A2)
          IF (I.GT.0)GO TO 60
          CALL RUPEN(ISTAT,IERR,NAME)
          GO TU 70
```

```
60     CALL RCRET(ISTAT,IERR,NAME,-1,1,0,-22)
70     CALL FILER(ISTAT,IERR,IF)
       IF (IF.EQ.-1)GO TO 1000
C
C      INPUT SCAN PARAMETERS.  A NEGATIVE ENTRY FOR SIZE
C      CAUSES REVERSE STAGE MOTION.
C
       WRITE(2,75)
75     FORMAT("STAGE SPEED?")
       READ(1,*)IRATE
       WRITE(2,80)
80     FORMAT("STRIP SIZE?")
       READ(1,*)IWDTH
85     WRITE(2,90)
90     FORMAT("NO. OF STRIPS?")
       READ(1,*)NSTRP
       IF (IRANG(1,8,NSTRP))85,95
95     WRITE(2,100)
100    FORMAT("Y STEP SIZE?")
       READ(1,*)LSIZE
       WRITE(2,110)
110    FORMAT("NO. OF LINES?")
       READ(1,*)NLINS
C
C      INITIALIZE PARAMETERS
C
       IXSET=0
       IYSET=0
       N=1
       NUM=1
C
C      TAKE ARRAY DATA, ROTATE TO CORRECT BIT POSITIONS,
C      UNPACK, SUBTRACT DARK LEVELS, RE-PACK
C      AND STORE ON REMOTE DISK FILE FOR ONE STRIP
C
115    DO 120 I=1,NLINS
       IF (ISSW(15))1010,130
130    CALL DMAIN(IBUF(2),128,LU(1))
       CALL ROTAT(IBUF(2),IBUF(2),128,NBITS)
       CALL UNPAK(IBUF(2),IBUF(130),256)
       DO 131 J=1,256
131    IBUF(J+1)=IBUF(J+129)-IDARK(J)
       CALL IPACK(IBUF(2),IBUF(2),256)
       CALL RWRIT(ISTAT,IERR,NAME,IBUF(2),128,NUM)
       CALL FILER(ISTAT,IERR,IF)
       IF (IF.EQ.-1)GO TO 1000
       NUM=NUM+1
       IF (I.EQ.NLINS)GO TO 120
       CALL STAGE(0,LSIZE,IXSET,IYSET,IRATE,IBUF,IO(2))
120    CONTINUE
C
C      CHECK FOR END OF DATA TAKING.  IF NOT FINISHED,
C      SLEW OVER TO NEXT STRIP AND TAKE DATA IN OPPOSITE
C      SCAN DIRECTION.
C
       IF (N.EQ.NSTRP)GO TO 1010
       N=N+1
       CALL STAGE(IWDTH,0,IXSET,IYSET,IRATE,IBUF,IO(2))
       LSIZE=-LSIZE
       GO TO 115
```

```
C
C     REMOTE FILE ACCESS ERROR
C
1000  CALL IOUT(100000B,1)
C
C     CLOSE THE FILE AND RESET STAGES
C
1010  CALL RCLOS(ISTAT,IERR,NAME)
      CALL STAGE(IXSET,IYSET,IXSET,IYSET,IRATE,IBUF,IO(2))
      IF (ISSW(15))10,135
C
C     THIS SECTION WRITES THE DATA ON DISK TO MT
C     IN THE CORRECT SCANNING SEQUENCE(RASTER)
C
135   LEN=128*NSTRP
      CALL IOUT(0,1)
      REWIND 3
      CALL ROPEN(ISTAT,IERR,NAME)
      CALL FILER(ISTAT,IERR,IF)
      IF (IF.EQ.-1)GO TO 1000
C
C
      DO 140 I=1,NLINS
      DO 141 J=1,NSTRP
      IF (ISSW(15))190,180
180   IF (J.EQ.1)GO TO 150
      J2=J/2
      IREM=J-2*J2
      IF (IREM.EQ.1)GO TO 160
      NUM=2*J2*NLINS-I+1
      GO TO 170
160   NUM=2*J2*NLINS+I
      GO TO 170
150   NUM=I
170   CALL RREAD(ISTAT,IERR,NAME,IBUF((J-1)*128+1),N,NUM)
      CALL FILER(ISTAT,IERR,IF)
      IF (IF.EQ.-1)GO TO 1000
141   CONTINUE
      CALL BFOUT(3,IBUF,LEN)
142   IF (IUNIT(3))142,140
140   CONTINUE
C
C
      ENDFILE 3
190   REWIND 3
      CALL RCLOS(ISTAT,IERR,NAME)
      PAUSE
C
C     IF SW BIT 0=1 AFTER RUN IS PUSHED, THE DATA
C     ON MAG TAPE IS READ RECORD BY RECORD AND PRINTED
C     ON THE TTY TO CHECK THE OPERATION OF THE SYSTEM
C     SW BIT 15=1 ABORTS TO STATEMENT 10.
C
      IF (ISSW(0))200,10
200   CALL BFINP(3,IBUF,LEN)
210   IF (IUNIT(3))210,220
220   DO 230 I=1, LEN
      IF (ISSW(15))10,225
225   CALL UNPAK(IBUF(I),IPIXL,2)
      WRITE(2,226)IPIXL(1)
```

```
      WRITE(2,226)IPIXL(2)
226   FORMAT(I4)
230   CONTINUE
      GO TO 200
      END
      ENDS

**END-OF-TAPE
*
```

Chen, Pi-Fuay
High speed parallel sensing scheme / by Pi-Fuay Chen and William W. Seemuller — Fort Belvoir, Va. : U.S. Army Engineer Topographic Laboratories : for sale by the National Technical Information Service, 1977.

33 p.; 25½ cm. (U.S. Army Engineer Topographic Labs.; ETL 0119)

Prepared for Office, Chief of Engineers, U.S. Army.

1. Scanning systems I. Title II. (Series) III. Seemuller, William W.